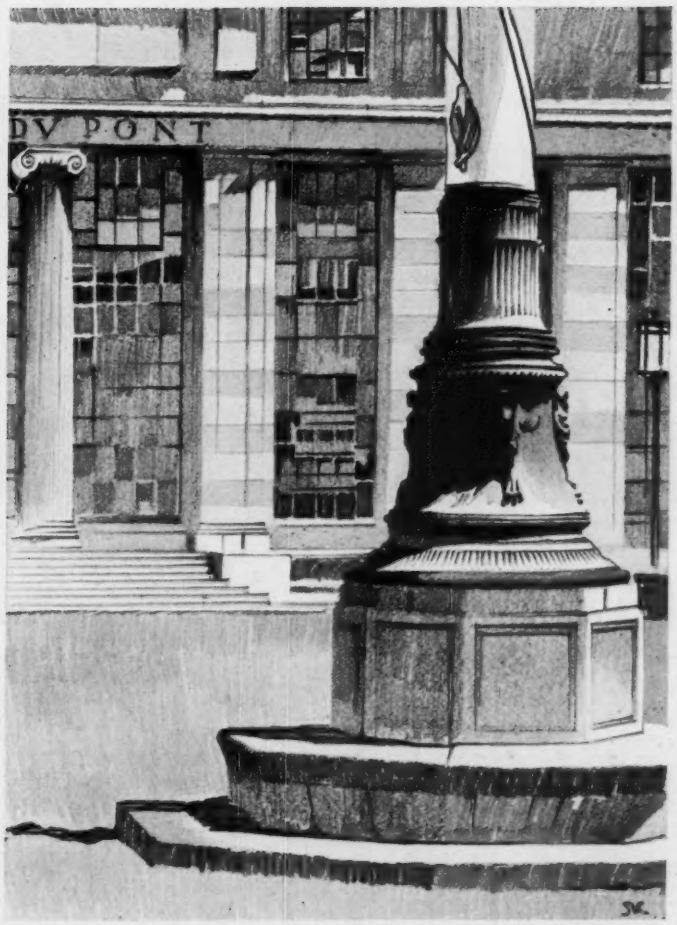
THE TECH ENGINEERING NEWS



NOVEMBER, 1932 VOLUME XIII, NO. 6
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Desert air *is wet*

. . . by comparison!

Making telephone equipment presents many an interesting problem to the engineers of Western Electric—manufacturer for the Bell System.

A case in point is the drying of telephone cable before putting on the protective lead sheath. This step is of utmost importance, for the tiny copper wires cannot carry your voice properly unless their paper insulation is thoroughly dried. To this end, Western Electric engineers devised special drying ovens in which the air is *thirty times dryer* than desert air!

The same ingenuity and thoroughness go into every step of making cable, telephones, switchboards and many other kinds of telephone equipment. The dependable apparatus that results is one reason why Bell System service is dependable.

BELL SYSTEM

A NATION-WIDE SYSTEM OF INTER-CONNECTING TELEPHONES

The TECH ENGINEERING NEWS

Volume XIII CAMBRIDGE, MASS., NOVEMBER, 1932 Number 6

COPYRIGHT 1932 BY THE TECH ENGINEERING NEWS

CONTENTS

FRONTISPIECE: SPLASHING STEEL 102

THE PROPHET'S WORD 103
By Richard L. Fossett

THE DEVELOPMENT OF RIGOROUS THINKING . . . 105
By Professor Richard Henry Frazier

OIL AND THE TECH MAN 106
By W. B. Ross

STEAM ON THE ROAD 108
By John E. Muhlfeld and Frank H. Moore, Jr.

EARTHQUAKES 109
By Ernest A. Hodgson

STANDARDS FOR THE RADIO 115
By Beverly Dudley

EDITORIALS 110

ENGINEERING DIGEST 113

RESEARCH IN REVIEW 114

THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman, WILLARD V. MERRIHUE
1 RIVER ROAD, SCHENECTADY, N. Y.

Armour Engineer
Auburn Engineer
Colorado Engineer
Cornell Civil Engineer
Illinois Technograph
Iowa Engineer
Iowa Transit
Kansas Engineer
Kansas State Engineer
Marquette Engineer
Michigan Technic
Minnesota Techno-Log
Nebraska Blue Print
Ohio State Engineer
Oregon State Technical Record
Penn State Engineer
Pennsylvania Triangle
Purdue Engineer
Rose Technic
Sibley Journal of Engineering
Tennessee Engineer
The Tech Engineering News
Wisconsin Engineer

John P. Mudd for The Midvale Company — *Army Ordnance*

SPLASHING STEEL

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME XIII NOVEMBER, 1932 NUMBER 6

THE PROPHET'S WORD

By RICHARD LEIGH FOSSETT

President of the Senior Class

Massachusetts Institute of Technology

FIFTEEN years ago Technology began a new existence on the site she now occupies. Up to that time she had no pretentious and stately dwelling, yet she gave to the world more than her share of men who are now acclaimed as the leaders of the era. Today she stands as an institution of inestimable prestige, the leader among engineering schools, and still she is growing — in all ways. Is it not fair that we ask: "What lies ahead?"

As a man speculates on the fate of himself and his environment, so the normal undergraduate wonders what the future may hold in store — not only for himself, but for his school. The experiences of students, curricular and otherwise, involve them so completely with so many aspects of Institute life that it is no wonder that innumerable suggestions for improvements of methods or equipment come from their comparatively short associations with the school. A majority of these ideas are fantastic; they savor too much of the ideal. Yet a good number of them are truly logical, and are worthy of incorporation in the future plan. In any event it is interesting to think of the Institute as it is and to imagine what it may be like in the future, in terms of the constructive plans which are suggested from time to time.

Can you imagine Tech in 1952? Think of what it was twenty years ago, in 1912. Will the school change physically as it has in the last two decades? Will it become primarily a Graduate School? How many students will there be? Will they be well-organized, or will they be apathetic to other activity? What will be the status of fraternities? There are hundreds of similar questions which may be asked, and each could be analyzed at length in the search for a logical answer. Student opinion is fairly well crystallized on some of the more important questions, and I shall attempt to present and analyze it briefly here.

Student Organization

The form of interest shown in various activities is changing from year to year. Large activities requiring concentrated interests are losing their hold. As men narrow themselves more to their professional studies, they seek *outside* the school for recreational opportunities. The recreation of endeavor is losing to the idea of recreation for the sake of recreation. For instance, students would rather *go* to a show than try to *give* one. The reason is not apathy, but the lessening attraction of success outside of professional work, and the offering of other ways of making social contacts.

Athletics is the best example of the desire for recreation as against that of excelling in an organized group. Within the last three years major sports have attracted less men, and the minor sports more. The reason why, lies in the attempts of men to get exercise quickly. Quite likely they have little competitive interest in the sport; they are interested rather in keeping fit physically. The aim is worthy, but it shows the diminishing need for organization. This analysis indicates a lessening organization strength, and in several decades it is likely that the present system of organized activity will degenerate to a weak control over a smaller number of students. This assumes that the number becoming interested in activities will lessen steadily.

Organized undergraduate control will still be a necessity for groups will still be formed for social purposes. It is likely to diminish to a type of simple administrative control, which will exercise itself, for example, in the designation of rules of conduct for various affairs. The central financial control existing at the present will cease altogether.

Walker Memorial

As the type of activity changes, will Walker Memorial become inadequate? Every student has heard the cry: "We want a bigger and better Walker Memorial." Twenty years ago there was no large hall where students could gather during their leisure time. Five years ago, in spite of all they then had, no student considered Walker satisfactory. It was unsuited to dances, and men wished to hold their social affairs where there

would be no hint of official restraint. Today the benefits Walker offers have been discovered, and some event is always taking place there. There are enough dances to suit any student. Banquets and parties are common occurrences rather than rarities.

In twenty years most of us hope and expect to see at least one wing added to Walker Memorial. The need is not urgent, but with the expansion of the dormitory system, the demands of its residents for more adequate social facilities, and the increased adaptation of the general student body to what Walker may offer, either Walker must be enlarged or the activity within it limited. What we shall see will be a large lounging and reading room, and perhaps another large hall to permit the separation of dining room and dance hall. This last addition would make a large space available, so that a majority of the students might gather socially at one time without being crowded.

School Policy from the Undergraduate Viewpoint

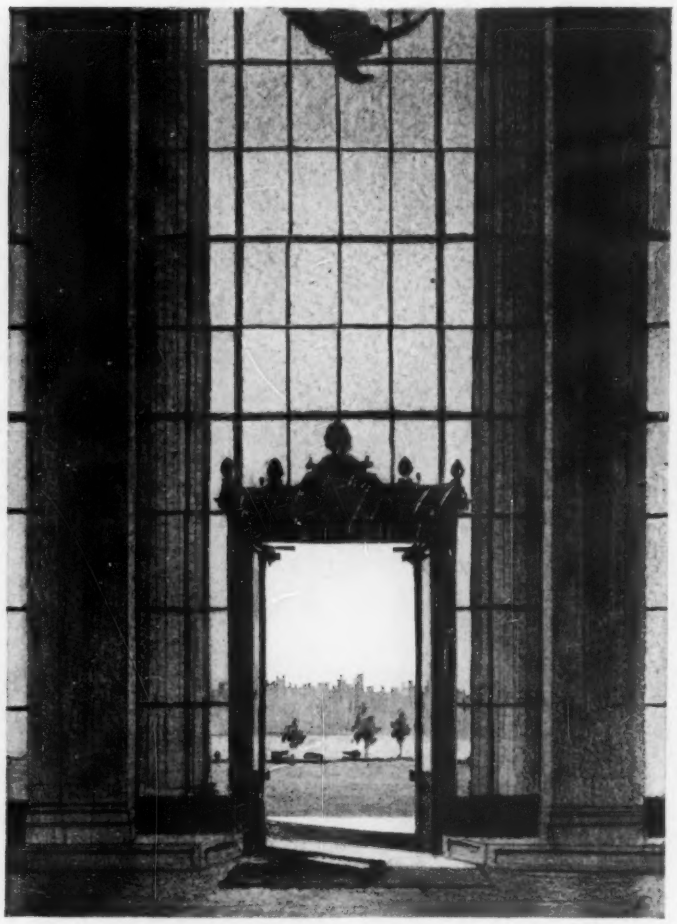
Those of us who are now seniors have seen many vital changes during our three years here. There has been a tuition increase to $500, a new dormitory, a new physics laboratory, and the establishment of a graduate school. Changes like these, coming in three years, surely indicate that twenty years will see an even greater change.

Even before the establishment of the graduate school Tech was famous for the opportunities it offered for graduate work. The prestige of our school has attracted men graduating from other institutions, who come considering Tech as a kind of highly specialized "finishing school." From a professional standpoint the improvement of standards for graduate work is a most noble plan. But the two schools, undergraduate and graduate, cannot live as one successfully. The graduate school will predominate because of its scholastic opportunities. The final result will be a growing impersonality, as increasing numbers of men come here for short periods to complete their education. A man will still consider his own undergraduate school as his Alma Mater, and will care little about what Technology stands for.

How many students will there be? It seems likely that the number in the undergraduate school will remain what it is, or slightly less, while the number of graduates will grow. It is probable that there will be a total of five thousand students, of which two or three thousand will be graduates. This is the expected consequence of the establishment of the graduate school and the growth of its reputation.

An increasing number of students presumes a larger plant to care for them. Twenty years will see more additions to the main set of buildings according to the set plan. Probably there will be several wings built adjoining the dome and behind it. And again, in terms of probabilities, the additions will be for the mechanical and electrical engineering departments.

What will a student have to pay to attend the Technology of the future? Students can only wonder about this vaguely, as they know little about the methods of financing operations. Under the present rate they rebel, of course, as perhaps they would under a lower rate. But financial statements show that the instructing service alone costs more than tuition, so the students are getting something for nothing, and will continue to do so unless the rates are raised. However, it seems likely that a maximum has been reached and that the tuition will remain $500, or an amount which would correspond to this under a different general financial situation of the country as a whole. Endowment will surely increase, but these funds will be used for permanent improvements, and to provide better equipment. With the tuition at its present rate no one can object to the return on his money, while the policy of limiting the number of students by control of rates, rather than by scholastic admission requirements, will never be followed.



Student Housing — Fraternities

The fraternity's first purpose is to provide a comfortable and pleasant place in which to live while attending college. When it fails in this duty it cannot continue to be acknowledged as successful. At M. I. T., the school is carrying out an extensive student housing plan, whereby men may live near the school, associate with their classmates, and enjoy comfortable quarters. Most of the fraternities cannot offer as much as this, although they still do make possible a more intimate relation of small congenial groups.

Fraternities will not die out nor decrease. They will be much weaker, and the dormitory groups will govern school activities. Most of the fraternities will move nearer the school. Perhaps Tech will assist in setting up a parallel housing plan — dormitories on one side of the main buildings, fraternities on the other. At any rate only the nearer modern houses will retain their strength. In less than twenty years, perhaps ten, dormitory men will be considered as the equals or superiors of the fraternity men.

Twenty years have passed. Memorial Drive has been transformed into a park by filling in parts of the river. In the background of the park, beautifully landscaped, with only the dome and the tops of the buildings

(*Continued on page 120*)

THE DEVELOPMENT OF RIGOROUS THINKING—
The Basis of Education

By *RICHARD H. FRAZIER*
Assistant Professor of Electrical Engineering
Massachusetts Institute of Technology

"My name is Benjamin Jowett;
I'm master of Balliol College.
Whatever is known I know it,
And what I don't know isn't knowledge."

BENJAMIN JOWETT died in 1893. Contrary to the above jingle attributed to Oxford students, it is doubtful whether anyone ever came closer to knowing practically all that was known in his time than Aristotle who died 322 B.C. Since that time, especially during the last few centuries, due largely to the development of more powerful modes of investigation and to specialization of effort the world's store of knowledge has grown so much more rapidly than the power of any one mind to encompass it all, that it now is possible for one person to become intimately familiar with only a very small part indeed, while at the same time it is becoming increasingly difficult to grasp a general view of the relationship of the parts. It is becoming more and more important therefore that the educational process should center about the development of the mind into an instrument of exact reasoning rather than into a depository for facts, supposed facts, and tradition. It is the thesis of this discussion that the educational process of the leading engineering schools of today affords the best means to this end, in that it utilizes the best available tools.

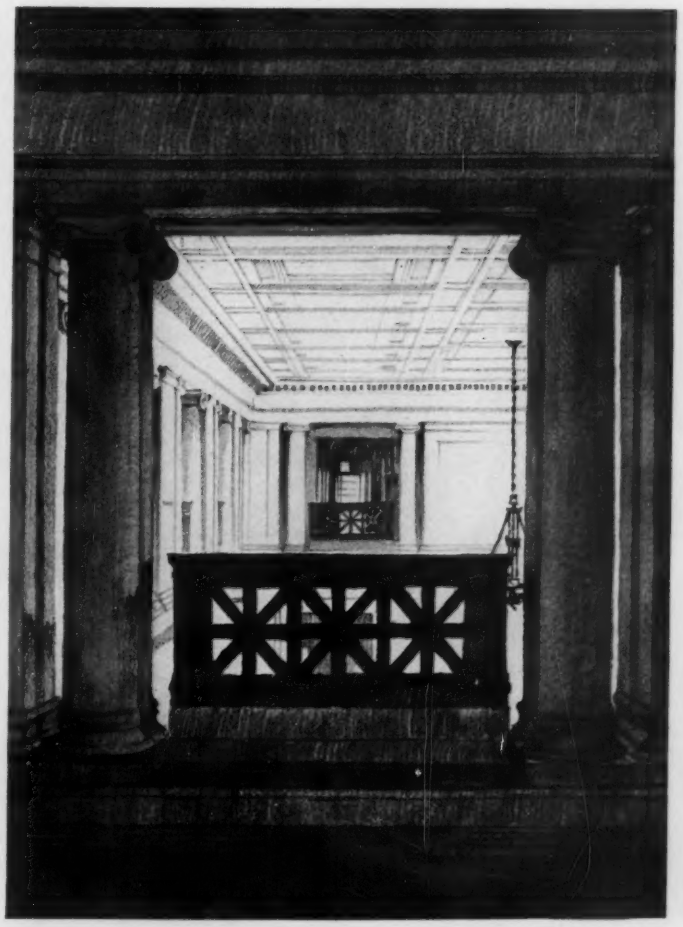
There still are a few die-hards who consider anyone devoid of Latin or even Greek "uneducated." There are many misinformed and uninformed persons who view the process of the college of liberal arts as "education," as opposed to that of the engineering school as "training," largely vocational; the one broad and "liberal," the other narrow and specialized. There are those who view the engineering school as "professional" and feel that the student planning to become an engineer should go first to a college of liberal arts for a "general education" before specializing.

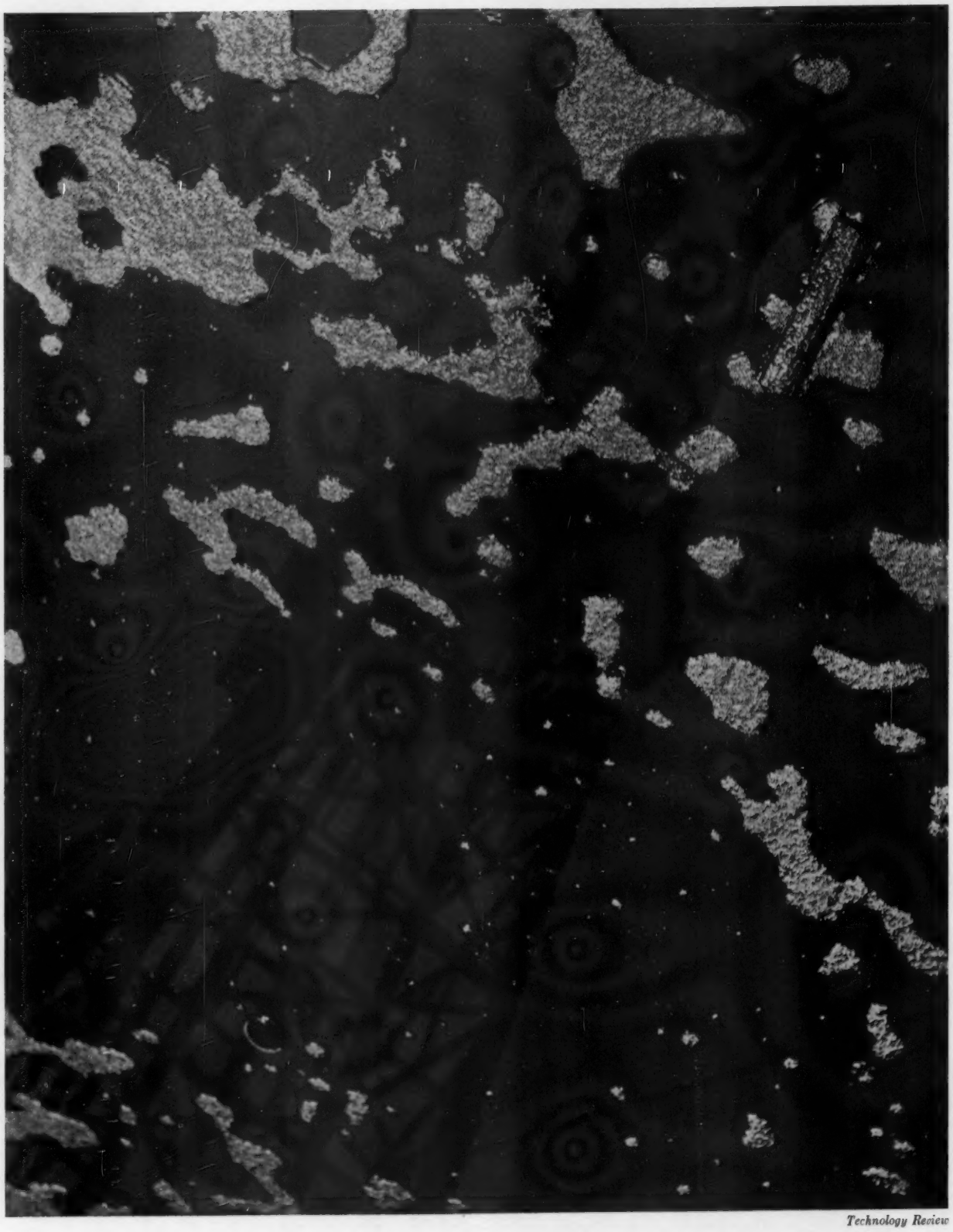
The undergraduate engineering school does not pretend to be a professional school in the sense that it emphasizes the detailed special information leading to the immediate practice of a particular branch or subbranch of engineering. It aims to develop the power of rigorous thinking through the study of scientific principles and their application. The principal educational tools of the engineering schools are mathematics and the more precise physical sciences. There is specialization to the extent that as the student advances he is permitted to bend his study toward and choose his illustrations and applications from one branch of science more extensively than other branches, according to his taste. Whether the mental processes are developed and tested through the medium of electricity and magnetism or thermodynamics is of no fundamental consequence, but it is advantageous to have the student working in a field which he finds interesting.

The media utilized by the engineering schools are supremely qualified for their purpose for two reasons: (1) their structure is such as to provide unsurpassed opportunities for the exercise of both inductive and deductive logic; and (2) the results of the reasoning process and the steps therein can in many cases be tested and verified by computation or experiment. There is no comparable opportunity in the study of languages and literature, history, religion, or the social sciences. Here the opportunities for the exercise of logic either are relatively meagre or are difficult to keep within bounds of possible verification. The latter is a situation which invites loose thinking and futile argument. Even in situations wherein the course of events can demonstrate the truth or falsity of a conclusion reached by reasoning, it is rarely possible to verify the entire process. Hence, if the conclusion reached proves to be false, it cannot be ascertained whether the reasoning was fallacious, whether unknown factors contributed to the situation, or whether the major premise was incorrect. Similarly, if the conclusion proves to be correct, there can be no assurance that it was not mere coincidence, the true explanation being quite otherwise than the one supposed.

It should not be inferred from this discussion that engineering schools regard the usual content of the curricula of the colleges of liberal arts as valueless or even as unimportant. The fact is that all engineering schools include a moderate amount of the so-called humanistic studies in their curricula, largely as guideposts for future study. The Department of Electrical Engineering at the Institute, for example, allocates

(*Continued on page 120*)





Technology Review

REFLECTIONS

OIL AND THE TECH MAN

By W. B. ROSS
Head of Chemical Engineering Division,
Research and Development Department, Vacuum Oil Company, Inc.

THE young technically-trained man seeking a position should consider the problems of any particular industry in which he is interested and the attitude of the industry toward solving these problems. If the industry has many problems the solutions of which are necessary for maintaining and advancing its position and shows an inclination to obtain a solution of its problems, it is an industry of opportunity. Research is necessary for the solution of the problems. Research is followed by development or process work, which if successful, leads to new materials for manufacturing and construction, new designs of equipment, new construction, new processes and new products to market. The petroleum industry meets these requirements.

Before considering the problems of the petroleum industry, it may be desirable to review briefly the progress which it has made in improving its processes and equipment. The first oil wells drilled in the United States were located in the vicinity of known oil or gas seepages. The first wells were drilled with an adaption of the method used for drilling artesian wells and the first refinery was simple distillation using a small tank and a condenser. Since that time these processes have greatly changed. The search for oil now depends on the greatly increased knowledge of geology and the use of geo-physical instruments such as the seismograph, the torsion balance and various electrical devices. Drilling has been improved by numerous steps to the present rotary rigs using improved tools and steels and several methods of determining the angle of deflection of the hole from the vertical. The recovery of oil from individual wells or entire fields has been increased by repressuring, flooding or water drive and by use of chemicals for changing the interfacial surface tension of oils to sand.

Crude oil was originally hauled in barrels in horse-drawn wagons. It is now pumped from the oil fields through pipe lines either to refineries or to the seaboard where it is loaded on tank ships. Many of these pipe lines are hundreds of miles in length. Finished products are shipped in tank steamers, tank cars, tank trucks, steel drums, barrels or cans, although there are some pipe lines used for transporting finished gasoline for considerable distances.

Distillation, usually the first step in refining, has passed through numerous stages from the single shell still, batteries of shell stills in series, shell stills with bubble towers and vacuum, to the modern high vacuum pipe still equipped with one or more fairly efficient bubble towers.

Chemical treatment of lubricating oils with sulphuric acid has long been practised with little modification. New methods of chemical treatment are now coming into use. Filtration by percolation through clay has been standard practice for many years but has been partially replaced by contacting with clay at elevated temperatures. Cracking for producing gasoline from heavier oils has come into general use and has been gradually improved by the use of higher temperatures and higher or lower pressures which, combined with improved chemical treatment, has given larger yields of higher anti-knock fuel without pronounced gum formation during use. Increased knowledge of the desirable characteristics for motor fuels has made possible the present fuels providing easy starting without vapor lock, good acceleration and maximum power without crank case dilution, and has required the design and installation of distillation equipment to produce such fuels.

Entirely new products have been produced from petroleum compounds by hydrogenation, polymerization, oxidation and synthesis. New metals and improved types of control and recording instruments have been of great assistance in these advances. Many of the present methods are thus developments of processes originally started many years ago while others are of quite recent origin. However, it is only within the last decade that new processes, new equipment or improvements in existing processes and equipment appeared with any frequency. It is within this same period that technical men have been employed in numbers in petroleum work, and it is very largely through their efforts that the present results have been obtained.

It must not be considered that the petroleum industry has attained its full growth. Many of its phases are still in their infancy while all of its processes are in need of modification and improvement. These changes comprise the technical problems of the industry and will be discussed briefly.

Crude oil is the necessary raw material and an adequate supply must be maintained. It is of the first importance to determine the origin of crude oil, the method by which it was formed, and if it is being produced at the present time. Research to obtain this information is now being carried on and should be continued and expanded. As the present more easily-located and readily-obtainable supplies are depleted, new or improved methods for locating oil-bearing strata will be developed, particularly for strata at great depths. Deeper drilling has already shown that in some fields oil-bearing sands exist below each other separated by layers of rock impervious to the oil. Improved methods of drilling would be exceedingly helpful for these deeper holes. The search for oil will also be carried to the more remote parts of the earth with the attendant difficulties of location, transportation, and maintenance. It is well known that more oil remains in an oil field than can be produced by present methods. Thus there is the possibility of greatly increasing yields from present fields if satisfactory processes can be obtained.

Corrosion exacts a tremendous toll in production, transportation and refining. New metals or coatings for the construction of oil well casings, pipe lines, tanks, stills and treating equipment could save many millions of dollars annually.

Increased severity of operating conditions in many kinds of equipment have required the continual improvement of petroleum products. Many of these products are approaching the highest quality that can be produced by present methods with present equipment. New manufacturing methods involving the separation, purification and modification of petroleum fractions or compounds are greatly needed. Some processes have also been greatly limited by the materials available for construction of equipment. Here again new metals and coatings more resistant to corrosion or more capable of

(*Continued on page 117*)

STEAM ON THE ROAD

By JOHN E. MUHLFELD, Consulting Engineer, and FRANK H. MOORE '34

THE steam locomotive first came into prominent notice in 1829, when the Liverpool & Manchester offered a prize of £500 for the best locomotive. Stephenson's *Rocket*, which easily won the prize, had many of the features of the modern locomotive. The steam was produced in a multi-tubular boiler, and the exhaust turned into the smokestack to stimulate the draft, as with modern practice. No more efficient device has been found, although experiments have been made with fan blowers.

In 1836, Eastwick & Harrison, of Philadelphia, built a 4-4-0 locomotive. It had an equalizing system to distribute the weight in the correct proportion among the several wheels. It was one of the first in America to embody several coupled wheels in conjunction with a leading truck. This locomotive embodied all the features of the modern machine except those known as specialties or auxiliaries.

The pressures carried in the boilers of locomotives have been increasing ever since the time of the *Rocket*, which used a pressure of 60 pounds per square inch. This increase has made possible more powerful locomotives and greatly increased thermal efficiency.

When the superheater, which further heats the steam after it is taken away from the water, was coming into use about twenty to thirty years ago, some railroads used a lower pressure on new locomotives with superheat than on older power without it. This tendency has now disappeared, and higher pressures are being used on each new design, while the modern superheater has about twice the area of the superheater of the period of the war. At the present time, most new locomotives carry from 235 to 250 pounds. Some have been built with 275, and one carries 325 pounds, but this is not common. At the same time, pressures of the order of 400 pounds are common in marine practice. Numerous public utility central stations in the United States now use 1,250 pounds, while some have gone as high as 1,500 pounds.

In order for the pressures in locomotives to be carried much beyond the present value, a new type of boiler is necessary. The modern locomotive boiler consists of a cylindrical shell containing water. A number of tubes and flues from two to six inches in diameter traverse the water space from end to end. At the front, these are in communication with the smoke box, at the top of which is the smokestack; at the back they are open to the firebox. It is the firebox which imposes the limits on the conventional boiler. It consists of two boxes, one within the other, the space between being filled with water and steam, and in communication with the barrel. The grate is placed at the bottom of the inner firebox. It is obvious that the cylindrical barrel cannot be deformed by pressure from within, and the tubes are so small that they are able to resist the tendency to collapse. The firebox is built up of large flat or irregularly curved plates. It is necessary to insert staybolts to connect the inner and outer fireboxes to resist the pressures of the steam and water.

In considering any new features for the steam locomotive it is necessary to consider the requirements, which are different from those of most power plants. The chief one is reliability, so that schedules can be maintained.

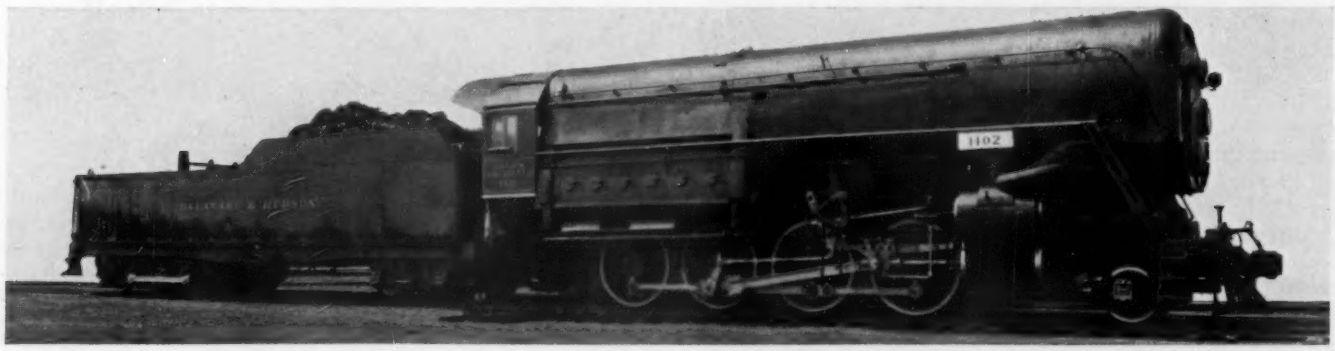
A most important factor of steam locomotive operation, which makes for greater efficiency and economy, is the length of run, which during the past few years has generally been increased from the conventional 100 to 150 mile run to 500-, 750- and even 1000-mile run without the engine's being cut off the train.

Another feature which a locomotive must have, especially in America, where labor is expensive, is low maintenance cost and long periods between shoppings, as well as short turn-around periods. A locomotive is earning money only when it is pulling trains, so that low maintenance cost and long intervals between shoppings are more important than high thermal efficiency. Economic conditions require that the initial cost be as low as possible, while the consumption of fuel must be reduced to the lowest figures consistent with reliability, long runs, and long intervals between shoppings.

The modern steam locomotive fulfills these conditions remarkably well. No other form of transportation can begin to compare with the railroads for reliability. Maintenance is very low. Some of the modern passenger locomotives will make over 200,000 miles and freight locomotives over 100,000 miles between general repairs. The modern steam locomotive is very cheap, costing less than half the price of an electric, and requiring no outside source of power. The cost is less than that of a medium-priced automobile, in proportion to the power.

Experiments have been made with water tube fireboxes carrying normal pressures, but in 1924, the first of abnormal pressures appeared on the Delaware & Hudson. In this design, the firebox consists of four longitudinal drums, which are rigidly connected to the

(Continued on page 116)



The High-Pressure Locomotive

EARTHQUAKES AND THE EARTH-STRUCTURE THEORY

By ERNEST A. HODGSON
Dominion Observatory, Ottawa, Canada

IT is significant that man knew, in considerable detail, the structure of the solar system, widespread about him, several centuries before he really knew anything of the structure of the earth beneath his very feet. His knowledge of the former was developed through data made available to him by seismic rays. The study of the celestial structure may be carried out by individuals in single localities. The emission of the light energy is continuous and observations may be made at known times, being subjected otherwise only to meteorological limitations. The seismic energy is emitted at times and from foci which cannot be predicted, nay, which must be determined after the event in every case, if the data of the earthquake concerned are to be useful. This requires that the attack on the problem of geostructure be a collaboration of effort; recording must be continuous, absolute time must be determinable for each recording station to within a second or less. The wonder is not that we have been so long acquiring what knowledge we have of the earth's internal structure, but that we have been able to arrange and to maintain the international seismographic collaboration required.

The foundations of any satisfactory geognostic theory must needs be laid by seismology. A particularly close coöperative effort on the part of workers in all the related sciences is, however, requisite for the rearing of its detailed superstructure. It often happens that the enthusiastic architect of such a theory pays too scant attention to the nature of the foundations on which he builds and fails to appreciate the relative strength of their various parts. We propose to consider the restrictions placed on the development of an acceptable theory by the basic deductions from seismographic data.

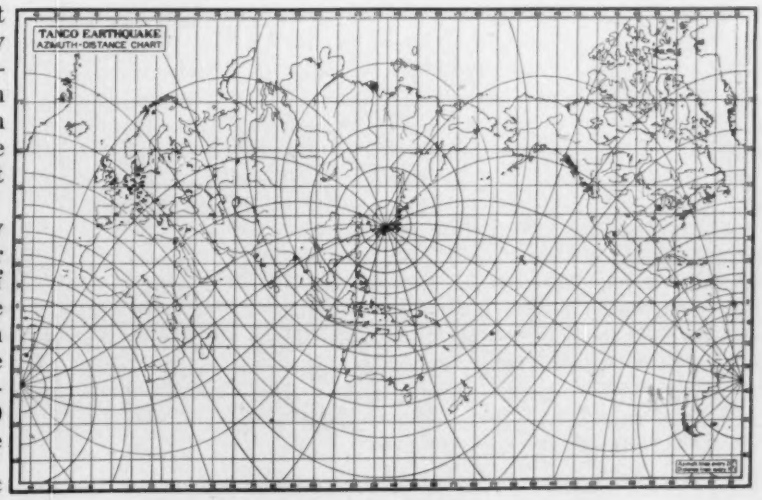
The evidence, which we shall examine more in detail presently, leads us to deduce that the earth is built up as a series of concentric spherical shells. Let us reduce the problem to its simplest terms. At a depth which, for present purposes, may be set down as forty kilometers, more or less, lies what we shall here call the upper discontinuity. It is recognized, however, that others less pronounced or at any rate less generally distributed about the earth, are found to exist above it in most of the few locations where a seismic study of this upper crustal structure has been made possible. This has been achieved by a concentration of well-equipped seismographic stations within a radius of five hundred kilometers or so of the epicenter of a sharply defined earthquake of not too great intensity.

For the purposes of this discussion we may disregard any discontinuity other than the upper one mentioned above and another at a depth of 2,900 kilometres, which we shall call simply the lower discontinuity. Let us think then of an earth made up of an irregularly layered crust lying above the upper spherical surface of discontinuity, beneath which to a depth of approximately 2,900 kilometers we have a thick spherical shell — the mantle. The lower boundary of the mantle is our so-called lower discontinuity. Below this we come to a sphere of radius approximately 3,760 kilometers — the core. Methods of studying conditions in the crust may here be termed crustal methods, those applicable to the intermediate shell mantle methods, and those peculiar to the inner sphere core methods.

The layer or layers lying above the upper discontinuity have been studied in detail only in three general regions, Europe, Japan, and California. Such studies can be carried out only where there is a concentration of well-equipped observing stations in a fairly active seismic region. Different researches have deduced depths to the upper discontinuity as we have defined it which lie within the range fifteen kilometers to sixty kilometers. Crustal methods for studying geostructure are most interesting, but their discussion, if adequate, would be too lengthy to be included in this paper. We shall devote our attention to the structure of the mantle and the core, considering crustal methods only so far as they affect the application of the other procedure.

At the time of an earthquake, energy is released from a focus which for our present purposes may be considered a point. This focus lies at a depth which is usually found to be less than thirty kilometers but which is in some cases of the order of 500 kilometers. This energy is propagated in the direction of diverging seismic rays by two types of elastic waves — compressional and shear. The velocities of propagation differ, the former being always the greater. Seismologists have adopted the term *P*-wave to indicate the preliminary or compressional wave, arriving first at an observing station. They apply the term *S*-wave to the secondary or shear wave. It is termed secondary because it arrives after the *P*-wave, but it is also of secondary value in determining earth structure since it is registered while the seismograph is still disturbed by the earlier phases and so may not be determined so precisely either as regards time of arrival, amplitude, or plane of vibration. The two velocities are frequently denoted by V_P and V_S respectively, where:

(Continued on page 118)



A Seismographic Chart

The TECH ENGINEERING NEWS

THE MANAGING BOARD

DONALD G. FINK '33, *Editor-in-Chief*
WILBER B. HUSTON '33, *General Manager*
CHARLES E. BUCHANAN '33, *Business Manager*
CHARLES T. STEWART '34, *Managing Editor*
FRANK M. HARTZ '34, *Treasurer*
JAMES B. WADHAMS '34, *Circulation Manager*
WALTER F. READ '34, *Advertising Manager*
EDMUND D. LUCAS, JR. '34, *Associate Editor*
JOSEPH L. SELIGMAN, JR. '34, *Associate Editor*

Editorial Department

GORDON K. BURNS '34 . . *Associate Managing Editor*
HENRY J. OGORZALY '35 . . . . *Assistant Editor*
HOWARD E. BERNHARDT '35 . . . *Features Editor*
C. WARREN BUBIER '35 . . . . . *News Editor*
CHARLES S. SUTTON '35, *Assistant Editor*

Contributing Editors

GEORGE P. BENTLEY '33 — C. B. GAMBLE, JR. '34 — FRANK H. MOORE '34 — WILLIAM R. HASELTINE '34

Business Department

J. GODFREY BORGER '34 . . *Associate Advertising Manager*
G. DONALD FENTON '35 . *Assistant Advertising Manager*
ALFRED R. JOHNSON '35 . *Assistant Advertising Manager*
F. S. DOYLE '34 . . . . . *Associate Treasurer*
W. M. WATSON '34 . . . . . *Associate Treasurer*
KENNETH D. FINLAYSON '35 . . *Assistant Treasurer*
HENRY B. KIMBALL '35 . *Assistant Circulation Manager*
ARTHUR W. GILBART, JR. '35 *Assistant Circulation Manager*

Staff

R. C. MADDEN '35 — M. GOODHART '35 — J. DALEDA '34 — P. C. COOPER '35

EDITORIALS

MAMMALIAN MAN

BIOLOGISTS do not hesitate to classify man as an animal, for his corporeal analogies to the higher vertebrates are most strikingly consistent. J. Arthur Thompson, renowned English naturalist, writes: "Bone for bone, muscle for muscle, blood-vessel for blood-vessel, nerve for nerve, man and ape agree." In spite of the distaste of certain people for the facts of their origin, such a similarity is evidently significant.

Evolutionists have delved into the annals of man's genealogy and have proven that man and the anthropoid ape are branches of the same parent stem. Such a startling exposition by Charles Darwin in the nineteenth century upset the entire Christian world: theology tottered on her lofty pedestal. Today, in spite of isolated cases like that of Scopes, the Tennessee school-teacher who was persecuted for his belief in biological evolution, Darwin's theory is accepted generally, despite certain "missing links" in the chain.

There is no denying man's superiority in many respects to the beasts of the field. Mentally he has far surpassed his foster-brothers. In the chaos of modern society with greed, jealousy, hatred, and malice often setting the torch to the dynamite of war, man often seems to have forgotten his debt to the earth that bore him. His sophisticated emotions are devils of his own creation; the animals are rarely temperamental. As civilized man strips his natural heritage of her riches, trees, minerals, animals, all, he should remember that he, too, is a part of nature, that he is merely one manifestation of her genius.

Surrounded on all sides by an ever more artificial environment, our minds clouded with cants, creeds, mythologies, dogmas, we may well become the slaves of civilization. Let us never forget that we are integral parts of the great natural scheme. Let us strive for clearer minds and a greater respect for this mysterious universe.

LEONARDO DA VINCI

IT is four in the morning. A pen scratches busily in a notebook partially filled with notes and sketches of the structure of birds and wings. The noise stops. Leonardo slumps forward and his long golden hair falls over his arms and notes. A quill slips from his hand, almost femininely fine. His face too has an almost womanly beauty, but the expression is full of vigor. He has almost completed his investigation of the possibilities of flying for men. After five years of aeronautical research he is satisfied that eventually man will fly; enough; tomorrow he will complete some studies of horses. The room is oddly appointed. We see the skeleton of a horse, a stuffed bear cub, a diving-bell, a human arm preserved in spirits, large shoes for walking on water, and two huge wings, one partially covered with fabric.

"Leonardo da Vinci," as Emil Ludwig says, "observed the accelerated motion of a falling body and found the law for which he was not looking — two centuries before Newton. He constructed the block and tackle and was the first man since Archimedes to record the principles of the lever. . . . He developed the Law of the Conservation of Energy. Before Galileo he discovered the law of virtual velocity. He stated the principle of gyration and of the vortex. He was the founder of hydrostatics and of the entire science of hydraulics."

He was skilled as a painter, sculptor, architect, musician, mechanic, engineer, and natural philosopher. In this day of the specialist how we may marvel at this genius of such all-encompassing versatility!

Leonardo was born at Vinci, a Florentine village, the son of a lawyer. When a youth he was sent to work in Andrea del Verocchio's studio, in the company of Lorenzo di Credi among others less celebrated. He soon learned all that Verocchio had to teach him and carried out designs suggested by his master with consummate skill. He was the first painter to recognize the play of light as among the most significant phenomena for the eye of the painter. The earlier schools had subordinated light and shade to color and outline. Leonardo made himself notable for his tonal effects in shading.

He loved to draw and study the unusual forms of nature: strange plants, rocks, unusual faces and figures of men, their odd expressions. He painted the "Mona Lisa" of the inscrutable smile between 1503 and 1506. In his subject, La Gioconda, the Neapolitan wife of Zanobi del Giaconda, he found a sitter whose face and smile possessed in a singular degree the haunting, enigmatic charm in which he delighted. He worked on her portrait, it is said, at odd intervals during four successive years, causing music to be played for his model that she might hold her rapt expression. Later the picture was purchased by Francis I for four thousand gold florins, and it now is the treasured possession of the Louvre Museum in Paris.

In addition to oils, Leonardo also worked with the pen, the silver point, and crayons. He appears to have been left-handed, as all his drawings are shaded downward from left to right. His eccentric habit of writing from right to left was more probably due to this natural bent rather than to a desire to conceal. Although da Vinci lived in an epoch of superstition, religious bigotry, and persecution, he survived, escaping the fell clutch of the Holy Inquisition, because of a tolerance and beauty of spirit.

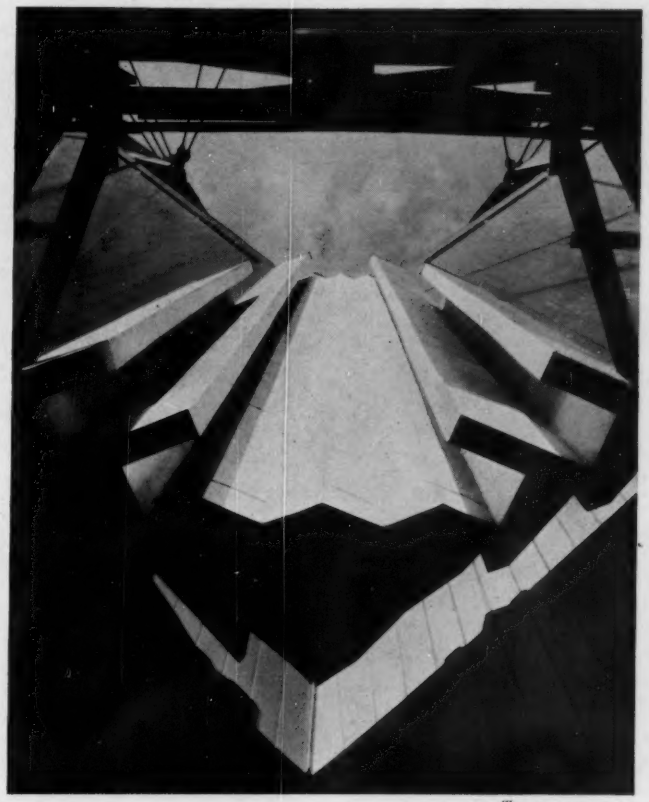
In 1492 he was busy with detailed plans for improving the irrigation system of the Lombard Valley and the adjacent plains. He was also engaged with plans for improving and strengthening the great Castello; was consulting engineer when the famous Cathedral of Milan was being built, and was called upon from time to time to design spectacular masques and mechanical wonders to entertain the visiting princes.

When Milan's crowded populace was decimated by the pestilential Black Plague, Lorenzo was ready with his suggestions for replanning and reconstructing the city on better sanitary principles. He even is said to have designed a theoretical two-tier roadway, in the improved metropolitan style.

From his manuscripts it is known that while painting an altar-piece he was writing to his correspondents about the tides in the Caspian and Euxine Seas. He served as a civil engineer in times of landslides and floods; in war he was made chief military engineer. As he wrote, while spending his last two years as a guest of Francis I of France, "Thou, O God, hast given all good things to man at the price of labor."

He heralded the work of others in the field of science. "Instrumental or mechanical science is the noblest and above all others the most useful." He wrote treatises on anatomy, astronomy, and botany, some of which are still good references.

"He lived spiritually alone, carrying many images of subtle beauty as well as much of the hidden science of the future." Leonardo had an unquenchable desire for knowledge for its own sake. He was a genial companion and a loyal friend. He is remembered today as one of the brightest stars in the dazzling constellation of Renaissance Art.



Technology Review

Looking upward toward the steel towers supporting the dome of the Travel and Transport Building at Chicago's 1933 World's Fair

IN MEMORIAM

THE TECH ENGINEERING NEWS notes with sorrow the passing of two nationally-renowned graduates of the Institute. Dr. John R. Freeman '76 was an hydraulic and civil engineer of wide repute, whose work is represented by such projects as the Charles River Dam, the Panama Canal, and the National Hydraulic Laboratory; and Professor Harrison W. Hayward '96, one of the best known members of the Institute faculty, was considered a leading authority on materials, and planned and developed the laboratories for testing materials here.

MILITANT PACIFICISM

WHEN the magazine *Liberty* prints an article showing how twenty thousand men could capture New York City; when students rise in rebellion against compulsory military training in the universities of this country; when new and ever more deadly means of human extermination are almost daily being devised, it is evident that serious thought is being given to the Next War. Almost everyone, save a few rabid militarists, will admit that war is the scourge of civilization, and that any war of the future will be so utterly annihilating as to dwarf the imagination.

Various methods of combatting warfare have been tried. The heroes of the World War believed, some of them, that theirs was a war to end war. War is still imminent. The League of Nations, the World Court and other means of international pacifism have been weighed and found wanting. Einstein, one of the keenest of modern pacifists, last year made an illuminating statement. He declared that if seven per cent of all the able-bodied men in the world were to pledge themselves to pacifism, the prisons would not be large enough to hold them in case of a war. War would be completely banished.

ENGINEERING DIGEST

Condensation of outstanding articles in the trade and scientific journals, published by special permission

AMERICAN POTASH

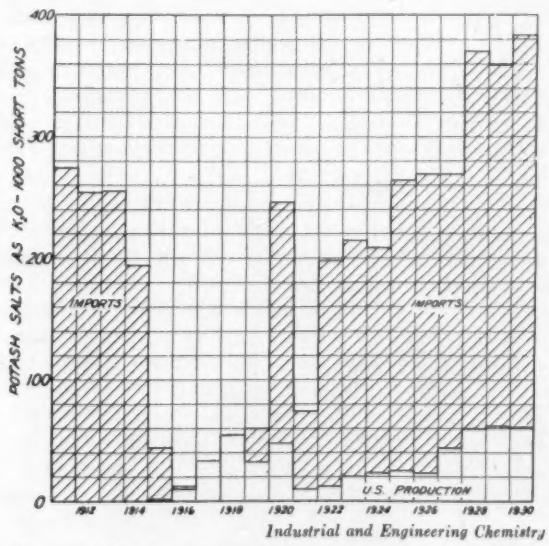
Industrial and Engineering Chemistry, *August, 1932*

EVERY high school student of chemistry learns that the United States has long been lacking in fields or mines of pure potash. The immense demand for this commodity, largely for use as a fertilizer — some 400,000 tons being required annually — has led to its gross importation from other countries. A moment's study of the accompanying graph will reveal the comparatively recent appearance of America on the horizon of potash production. The following figures compare the production of potash in this country with that of two leading sources of its supply, the numbers in tons:

Year	*U.S.A.*	*Germany*	*France*
1919.....	32,474	1,050,000	104,000
1921.....	10,171	1,165,000	158,000
1929.....	61,590	1,960,000	545,000

It is interesting to realize that prior to the World War absolutely no potash was obtained within the United States, and that the figure for 1915 was but 1,090 tons.

The famous Stassfurt deposits in Germany and in Alsace, France, contain enormous amounts of potassium and other salts. Their occurrence is explained by the evidence of a vast ocean of former times, which in some way became cut off from the rest of the earthly waters, slowly evaporated, and precipitated these valuable salts at its center. For many years the quality of the Stassfurt extractions has so far excelled that of all others that no chemical treatment has been necessary to stimulate its sale. Shipped by the thousands of tons, the crude potash was imported by many countries. The World War abruptly terminated our importation of potash, which is also a vital raw product in the explosive industry, and served to animate the hunt within our own borders. As a result, several hastily assembled plants were put into operation. It had been recently found that Searles Lake in California, in addition to its known sources of borax, was a potash field. Kelp, a coarse brown type of seaweed, which was the principal source of potash before the discovery of the German deposits, was exploited as well as several minerals containing



Chemical ingenuity is boosting America's potash production

Nitric acid makes short work of porous wyomingite

potassium found in southeastern New Mexico and in Texas.

After the War, manufacture and importation of potash dwindled, but in 1922 a steady increase was begun which is still in progress. At the Searles Lake plant of the American Potash and Chemical Company, a 50 per cent increase in production capacity has taken place within a year so that it now makes 120,000 tons K_2O a year. Concurrently, in New Mexico, the United States Potash Company has started our first plant, making a water-soluble salt as a direct result of a mining process. Different minerals containing potassium naturally vary as to composition. In Superior, Wyoming, a typical mineral, aptly named wyomingite, is made up of: SiO_2, 53%; K_2O, 11%; and small amounts of aluminum, iron, magnesium, and calcium oxides.

Real chemical ingenuity is required to devise methods of extracting potash from such ores. The following is one of several modern experimental methods of solving the problem. Treatment of wyomingite rock with nitric acid and oxides of nitrogen extracts 70 per cent of its metallic constituents as nitrate salts. By evaporation of the resulting solution to obtain the nitrate salts and by their subsequent roasting at a temperature of about 850 degrees C., nitrogen is evolved, while the potash and alumina combine as potassium aluminate. The latter, being water-soluble, is leached out of the roasting material, thus effecting a separation of these valuable constituents.

The next step in a process utilizing these reactions would be the conversion of potassium aluminate to potassium nitrate and alumina hydrate. The potassium aluminate solution, being quite alkaline, is an ideal medium for the recovery of nitrogen oxides unabsorbed in the rock-extraction unit. When this solution is neutralized, the potash is converted to potassium nitrate, and the alumina is precipitated as its hydrate. After filtering and washing, the latter need only be calcined for its conversion into alumina capable of entering directly into the production of aluminum.

The maximum over-all recovery of potash and alumina from wyomingite now appears to be only 67 per cent, which, however, is satisfactory when one considers the fairly low cost of processing made possible by cheap nitric acid.

ELECTRIC ARCS

D. F. MINER. The Electric Journal, *September, 1932*

ELECTRICAL discharges are familiar to all of us in the form of natural lightning. Many a summer night is made both beautiful and terrifying with reflected flashes and vivid bands of fire. The old conception of lightning as a broken zig-zag line is no longer held; even artists and advertising men now represent it as it really is — a flaming river full of twists and bends.

The practical engineer regards arcs as enemies to be outwitted, for when they occur on power lines they represent insulation failure and suspended service. To the pure scientist, the student of natural phenomena, or the artist, however, arcs are frequently beautiful, sometimes odd, and always interesting. The photographs appearing on this page give a suggestion of the many forms taken by electricity "on the loose."

Natural lightning resembles a system of rivers, with many tributaries branching off from the main stream. The only true zig-zag lightning is that obtained when the path of discharge is artificially controlled by furnishing a conducting path such as a small wire or a wet string.

An entirely different type of high-voltage discharge is produced by means of huge transformers, delivering an alternating voltage. The 60-cycle arc takes on the character of a flame, in general accompanied by a resonant hum which grows to a roar if enough power is released. A 50 foot column of flame produced with a million-volt transformer is illustrated in one of the photographs.

Under some conditions the flame of a 60-cycle arc develops a delicate tracery, a series of striations caused by the arc being extinguished and re-established 120 times a second. When air currents fan the arc to spread out these markings, the striated arc may appear as shown in the upper photograph — a delicate gauze of interwoven lines of flame.

Sixty-cycle striated arc — a cobweb of flame

The Electric Journal

A roaring column of flame 50 feet high: 1,000,000 volts A.C. turned loose

ST. LAWRENCE WATERWAY

THEODORE MARVIN

The Explosives Engineer, *October, 1932*

WHEN North America's greatest engineering project — the Great Lakes-St. Lawrence Deep Waterway — is completed, it will stand as a symbol of the fine coöperative spirit which has been shown by the United States and Canada in overcoming political differences, local commercial prejudices, and tremendous engineering odds.

This great potential waterway has long been under the scrutiny of navigators. Since the early days of the Jesuits, numerous construction projects along the river have been under way, a notable recent success being the new Welland Canal.

The Great Lakes–St. Lawrence Waterway, upon its completion, will provide a 27-foot channel from Montreal through the many hitherto non-navigable sections of the St. Lawrence River, around Niagara Falls, and up the Great Lakes to the lake cities of the United States and Canada. A channel of more than 30 feet in depth is now available from Montreal to the sea. The completion of the waterway will admit 90 per cent of all ocean shipping from the Atlantic Ocean to the Great Lakes and will lessen the economic handicaps of adverse transportation costs to a vast area in the interior of the continent — an area which includes a third of the states in the Union and much of Canada, and contains over 40,000,000 inhabitants.

Let us consider some of the main problems involved in building the Waterway. It happens that Lakes Michigan and Huron possess the same surface level. The former involves no special problem in the project except as presented by the Chicago Drainage Canal and the water it diverts for sewage disposal purposes — a matter of real importance, because the water levels of the lake group can be lowered appreciably by a disturbance in the natural drainage system. For instance, the dredging of sand in St. Clair River between Lakes Huron and Erie has noticeably lowered the level of Lake Huron. Too much diversion at Chicago similarly will affect the water level at the loading docks at Cleveland and other lake cities.

Regulation of flow into and out of the Great Lakes is also necessary for other practical reasons, and for the preservation of Niagara Falls. As it is during high water periods that unusual erosion takes place at Niagara, the reduction of the excess volume of water flowing out of Lake Erie will slow down the recession of the Falls' brink.

A map of the St. Lawrence River region will be of aid in following the actual specifications of the treaty. In abridged form, these are:

1. In the International Section, Canada will build and operate the works in the Thousand Island Section below Oak Point, and a canal and lock opposite Crysler Island.

(Continued on page 119)

RESEARCH IN REVIEW

Course I

During the summer the Winner seismometer, which was ordered two years ago, was installed at Camp Technology, Machias, Maine, in a building especially constructed for it, and has been recording earthquakes for the past three months. Reports are sent weekly to the United States Coast and Geodetic Survey in Washington. This is now the most easterly seismometric station in the country and should furnish valuable data.

The starting accelerometer developed by Brownlich under the supervision of Prof. G. L. Hosmer has been installed by the United States Coast and Geodetic Survey at various stations and has proven successful.

Course II

New light will literally, as well as figuratively, be thrown on the behavior of water inside centrifugal pumps, when a machine now being installed in the Steam and Hydraulic Laboratory is completed. Under intense electric illumination, the flow of water in the whirling rotor will be photographed through a glass window by means of a camera whirling at the same speed.

Course V

Chemical Research at Massachusetts Institute of Technology received a powerful stimulus last summer when the physical chemistry division of Course V moved into the new Eastman Laboratories. Keeping pace with modern developments in theoretical chemistry, studies are now under way on the properties of water and steam at high temperatures and pressures, the deviation of the temperature scale of the platinum resistance thermometer from the thermodynamic scale and numerous other subjects. Measurements are being made on the heats of neutralization and of dilution by the method of continuous flow calorimetry.

Student Research

The investigation of the mechanism of chemical reactions is being followed by the methods of photochemistry. To this end the absorption and emission of radiation by simple molecular systems are being studied together with the accompanying chemical changes.

The work on the thermodynamic properties of water and steam is a part of a large coöperative effort which is now reaching completion. On the basis of the data obtained, steam is now being generated in commercial plants at thirty-five hundred pounds pressure and almost at a dull red heat.

The Research Laboratory of Inorganic Chemistry constitutes the youngest of the chemical research laboratories at Massachusetts Institute of Technology. At the present time several outstanding problems are under investigation. These include a search for the lower valence compounds of the elements in group IVa of the periodic classification; the preparation and properties of the mixed halides of silicon, in particular, the fluorbromides of silicon; and the thermal decomposition of thionyl chloride. The influence of added inorganic compounds upon the rotation of polarized light by optically active substances, constitutes one of the latest problems to be undertaken by the laboratory.

Course VI

One fifty-thousandth of a second and it's over, but while it lasts it's the brightest light on earth! For the photographing of objects moving at high speeds, Dr. H. E. Edgerton has developed a light source which utilizes the intense flash of a heavy condenser discharge. One photo thus taken has shown that a golf ball becomes almost hemispherical while being struck with a driver!

Course X

When subjected to combinations of high temperatures and high pressures most real substances deviate in behavior from the so-called "perfect laws." This is particularly true of the hydrocarbons, such as occur in petroleum. The increasing use of elevated temperatures and particularly elevated pressures in the processing of petroleum has made necessary a more thorough knowledge of these deviations in order that equipment and methods may be properly designed. Under Dr. Lewis' direction rapid progress is being made in obtaining data and in classifying and coordinating the available information regarding the thermodynamic properties of the hydrocarbons.

Rubber belongs to the general class of amorphous materials and in common with other members of the same classification is not as easily represented in a mathematical formulation of behavior as are the crystalloidal materials. However, its industrial importance in the form of vulcanized articles has made it the subject of intense investigation. Its relative cheapness makes it an attractive chemical raw material. Under Mr. Squires' direction, the behavior of rubber is being studied in a well equipped rubber laboratory.

From the standpoint of utilization as chemical raw materials, enormous quantities of gaseous hydrocarbons, in the form of natural and refinery gases, are wasted each year. Studies of such possible means of utilization as cracking to form more valuable hydrocarbons. oxidation to solvents, high pressure hydration to alcohols, etc., have been undertaken in the Research Laboratory of Applied Chemistry under the direction of Professor Marek.

Course XVII

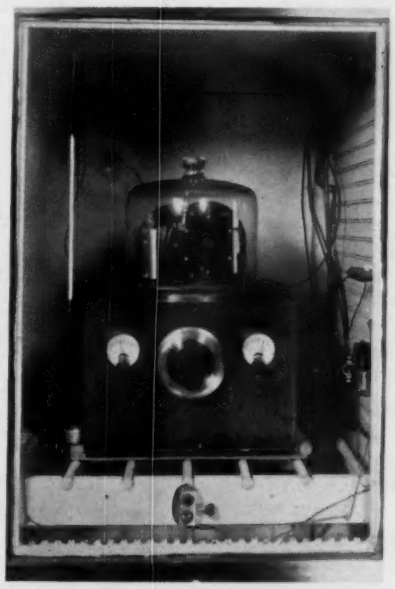
Just how water-tight different types of supposedly moisture-proof brick masonry really are, is a matter which the Building Construction Department is preparing to investigate thoroughly during the next several years.

STANDARDS FOR THE RADIO

By BEVERLY DUDLEY '35

IF we consider the state of affairs which would exist without it, the advantages of standardization immediately become evident and assume the importance which they deserve. If, for example, no standards existed for so simple a device as an ordinary machine screw, it would be necessary to turn out on a lathe a new screw to meet a particular set of conditions whenever a replacement became necessary. But since a machine screw for almost any reasonable requirement may be obtained from the local hardware store for a small sum, the replacement unit is bought without the least thought being given to the standardization which made such a purchase possible.

A standard may be defined as "that which is established by authority, custom, or general consent, as a model or example." Although the standard units of the fundamental concepts of time, length, and mass are perhaps the most important and at the same time the most familiar with which we have to deal, these are but few of the numerous standards which simplify manufacturing processes, reduce the cost of the finished article, and contribute materially to the convenience of our complex mode of living. Standards may be, and actually are, for example, set up on nomenclature, symbols and abbreviations, specifications for materials, uniformity of dimensions to insure interchangeability of parts, and methods of test and test procedure for the benefit of industry, for it is realized that perhaps one of the greatest wastes in industry is due to the failure to carry out the principles of standardization in a systematic, logical manner.



One of the 100 kc piezo-electric oscillators used as a basis for Bureau of Standards primary frequency standard

But this does not mean that all standardization is an unmixed blessing, for premature general consent along any one line may result in standards which will retard rather than advance general development, and the publication of material as a standard without the general consent of those primarily and actively interested in the project covered by it, results in the "standard" becoming useless through its failure of acceptance. Indeed, the publications of such material may be quite damaging by giving incorrect impressions to one not thoroughly versed in the field, and may lead to serious technical and legal difficulties and misunderstandings. Thus, the authority establishing a standard has a definite obligation to meet, as well as an excellent opportunity to serve a particular industry or group of individuals.

In the engineering and manufacture of radio equipment, standardization is as vitally important as in any other complex industry. The need for vacuum tubes having standardized dimensions so that a given tube will fit the particular socket for which it was designed will be obvious to anyone who has had occasion to replace a vacuum tube in his broadcast receiver. The necessity for vacuum tubes of the same type having as nearly identical characteristics as is commercially feasible may not be so apparent to one who has not studied the problem. Nevertheless, if the receiver is to operate in its normal manner, the uniformity of the electrical characteristics of the tubes is just as important as standardization of its physical dimensions. To be sure that the manufactured product will come within the limits of commercial acceptability it is necessary to compare it with a similar unit which is designated as a standard, or to measure the product by means of equipment which will permit interpretation of its readings in terms of dimensional values, certain ones of which are designated and recognized as standard. But in either case some standard is essential for purposes of measurement and comparison.

In the radio field, standardization of national scope is carried on almost entirely by the National Bureau of Standards, the Institute of Radio Engineers, and the Radio Manufacturers Association. Although the work of these three organizations is along different lines, there is general coöperation among them which guards against confusion.

The National Bureau of Standards assists the radio industry by maintaining the legal standards of inductance, capacitance, resistance and frequency. For a nominal amount, laboratory or commercial standards of these quantities may be calibrated by the Bureau to provide the working standards for the engineer or manufacturer. The Bureau transmits standard frequencies from its station WWV in Washington, D. C., which are heard in practically all parts of the United States. These transmissions are utilized to calibrate frequency standards, monitors, and receiving apparatus as well as for determining and adjusting the frequency of a transmitting station to the frequency assigned to it by the Federal Radio Commission. The frequency of WWV is controlled directly by the Bureau's primary standard of frequency consisting of a series of piezoelectric quartz plate controlled vacuum tube oscillators driving a synchronous clock.* The accuracy of the transmitted frequency is at all times better than one part in five million, so that through the use of these signals, frequency calibrations can be made almost anywhere in the country, which, because the dangers of transportation are avoided, are more accurate than calibrations made by sending the equipment directly to the Bureau.

The Institute of Radio Engineers is a society of engineers, physicists, executives and other individuals working primarily in the engineering side of radio communication. Its standardization activities are therefore largely directed to problems of an engineering nature, and in general the I. R. E. confines this part of its work to the preparation and publication of standards on technical nomenclature, graphical and mathematical symbols, engineering abbreviations, methods of testing radio equipment, test procedure, and safety precautions.

* Although a detailed description of the Bureau's frequency standard has not yet been published, a good idea of the equipment used may be obtained from a description of a similar standard in "High Precision Standard of Frequency" by W. A. Marrison, Proc. I. R. E., vol. 17, no. 7, pp. 1103–1122, July 1929.

(*Continued on page 119*)

LOCOMOTIVES

(*Continued from page 108*)

boiler. The two at the top are filled with steam; the two at the bottom are full of water. Vertical tubes, also filled with water, connect the upper and lower drums, on each side, while horizontal tubes form the top of the firebox. The drums are connected at the back by the rear header, which consists of two flat parallel plates, connected by staybolts. This construction has been found quite satisfactory. The intermediate header and front header, which produce rigidity, are of the same construction.

When these locomotives are operating in compound gear, the superheated steam enters the right, or high-pressure cylinder, where it expands, and is then exhausted to the receiver. From the receiver, it passes to the left, or low-pressure cylinder, where it again expands, and is exhausted to the atmosphere. When the engine is operating simple, the high-pressure cylinder exhausts through an independent exhaust to the stack, and live steam is admitted to the low pressure cylinder, at a reduced pressure.

This practice, called compounding, is not common in American locomotives, but with the general introduction of higher pressures, compounding is necessary to take full advantage of it.

Of the three Delaware & Hudson locomotives now in service, the first was the *Horatio Allen*, built in 1924, which carries 350 pounds per square inch. *John B. Jervis* followed in 1927, carrying 400 pounds, and *James Archibald* in 1930 with 500 pounds. A new locomotive, now under construction, will also carry 500 pounds.

The new locomotive is of the 4-8-0 type, and weighs, exclusive of tender, 390,000 pounds. The arrangement of the engine is unique. There are four cylinders, all outside, two in the conventional position at the front, and two at the rear. The steam first passes to the rear right, or high-pressure cylinder, then to the rear left, or intermediate-pressure cylinder, then to the two front, or low-pressure cylinders. As far as is known, this is the first triple expansion locomotive ever built. There is nothing impractical in this arrangement, as triple and quadruple expansions have been used on ships for many years. The tractive power in triple expansion gear is 75,000 pounds; in simple, 90,000 pounds. In addition, this locomotive will be equipped with a tender auxiliary locomotive, which will develop 18,000 pounds. This power is very great for a locomotive with only eight drivers.

The new locomotive will be equipped with an exhaust steam heater, a smokebox economizer to further heat the feed water, preheated air for combustion, roller bearings on the driving axles, poppet valves for the cylinders in combination with a rotary cam type of valve gear, and various minor details differing somewhat from the *James Archibald*. By means of the poppet valves and rotary valve gear as a substitute for the piston valve and Walschaert or other type of outside valve gear, the steam distribution will be improved and the back pressure on the low-pressure pistons substantially reduced, thereby increasing engine horsepower and reducing the coal consumption per horsepower hour. The four cylinders will transmit their power to a single driving axle, as the front and back connecting rods act on the same crankpin. This will distribute the thrust over the entire frame, instead of concentrating it on the front part, as in the usual manner. This locomotive will undoubtedly develop more horsepower per unit of weight than any steam locomotive in existence.

In Germany and England, locomotives have been built of the Schmidt-Henschel type, using a maximum pressure of 1,250 pounds pressure for the purpose of indirectly generating steam at 850 pounds, which is used in one high-pressure cylinder, and steam at 200 to 250 pounds which is used in two low-pressure cylinders. In other words, about 60 per cent of the power is produced through the use of 850 pounds, and 40 per cent through the use of 200 to 250 pounds pressure. The Canadian Pacific and New York Central have recently built experimental locomotives of this type. The first cost of such a machine is enormous, and the maintenance would be much greater than on the conventional locomotive, or those of the Delaware & Hudson. It is yet to be seen whether these boilers can be satisfactorily operated without a forced system of boiler water circulation, and as to whether the saving in fuel justifies the increased expenditures of the more frequent shoppings, and the greater possibility of engine failure.

In England, a locomotive has been built in which the entire boiler is of the water tube type, being not unlike the fireboxes of the Delaware & Hudson, except that the flexibility due to the suspension of the water tubes from the upper steam drum may result in leakage and other difficulties. This construction does not seem necessary, since the fire tube barrel is easy to maintain and able to withstand high pressures. The pressure used here is 450 pounds, less than that of the *James Archibald*.

Turbine locomotives have been built in Europe, but they are of small power compared to a typical American locomotive. To develop full efficiency, a turbine must have a condenser. No space is available to install a condenser of sufficient size for a modern American locomotive. The reliability and low maintenance costs of a turbine locomotive have yet to be proved.

Diesel power has been used for small trains, consisting generally of a motor car and trailer, and in some cases, for locomotives. The most powerful of these was built for the Canadian National several years ago, and no more have been built. The detonation in the cylinders of a Diesel engine is enormous, producing a high impact on the reciprocating parts. As a result, lubrication is practically impossible, and crankshaft failures are frequent.

Several years ago, it was believed that the steam locomotive had reached its limit of capacity. Since then, it has been so improved that it can handle practically any traffic needs. As a result, several roads contemplating electrification have dropped the idea. The enormous cost of electrification makes it impossible for any but a few roads to engage in any large electrification, while the increased capacity and efficiency of the steam locomotive makes general electrification unnecessary. As an example of the cost of electrification, consider the Pennsylvania between New York and Washington. A review of a program budget for this work has developed that of $100,000,000, $45,000,000 toll will be spent for new electric locomotives, and motor cars, and $55,000,000 to $60,000,000 will be expended for the purpose of conveying (not generating) the purchased power from the source of supply to the locomotives and motor cars; in other words, the outside source of power which is not required in steam operation. The cost of an electric locomotive is about twice that of a steam locomotive of approximately the same capacity. The costs mentioned above do not include the cost of current purchased from a power company. This current requires enormous investments to generate it.

It seems, therefore, that the steam locomotive, with reciprocating engines, will continue to be the chief agent of transportation in the future as in the past, especially when we consider that with a steam locomotive of 500 pounds pressure, a thermal efficiency which is greater than that of an electric, in terms of the heat value of the fuel at the tender drawbar.

OIL INDUSTRY

(*Continued from page 107*)

withstanding high pressures and temperatures are required.

Probably the most important field of future development is the preparation of new products from petroleum. At the present time certain large petroleum fractions and by-products of refining command a very low price and are scarcely marketable. These fractions provide a tremendous supply of cheap hydrocarbons available for conversion by synthesis. The coal tar industry was founded on a raw material less abundant, more expensive and containing fewer individual compounds. Very little is known concerning the exact composition of petroleum. Crude oil is extremely complicated in composition and probably contains thousands of compounds. Prolonged research is necessary to increase this fundamental knowledge. Research must be the foundation for all future development but progress along all lines follows in the path of research.

It is apparent that the petroleum industry offers opportunities to men of a wider variety of technical training than most others as it is one of the few major industries that covers the entire field from the prospecting for its raw materials to the marketing of its finished products in the proper form for use without further modification. It also provides to a large extent the means of transporting its raw materials and finished products. Chemical engineers, chemists, mechanical engineers and automotive engineers, physicists, electrical engineers and civil engineers are employed in considerable numbers. Somewhat less directly connected with the major operations of production, refining, distributing and marketing but nevertheless a necessary part of the personnel are doctors of medicine, sanitary engineers, safety engineers, naval architects, mining engineers and others. The present depression has to a degree lessened the number employed in these fields, but has not changed the scope of the work and there will be additional men required when conditions become normal.

The preceding has indicated the necessity for the employment of trained men for the technical progress of the petroleum industry. There is also opportunity in the direction of management. For years and even up to the present time the majority of the executives of the petroleum industry have been men who have come up through the ranks. There men have been largely self-educated through experience, but the tremendous expansion and prosperity of the industry is a good indication of their ability. The young technical men entering the industry have a decided initial advantage over untrained men, but they must not rely on a good start for continued promotion. They will be competing with many men of equal training. Straight and constructive thinking, imagination and the development of executive ability are essential. The rank obtained will depend entirely on the amount of properly directed effort expended and the highest positions in the industry will open to those who sufficiently direct and apply their energies.

Fig. 651. Flanged, Jenkins Standard Iron Body Gate Valve

Accuracy—

in goal shooting or valve making

Goals in basketball are seldom the result of chance. A high degree of accuracy is called for.

Accuracy counts for as much in manufacturing and the making of Jenkins Valves is a good example. Accuracy enters into every operation from the choice of metals by competent metallurgists to the rigid testing of the finished valves.

Castings for Jenkins Valves are sound and flawless, inspection systematic and constant. Machining is precise, assembly painstaking.

There are Jenkins Valves of bronze and iron for practically every power plant, plumbing, heating and fire protection equipment.

JENKINS BROS.

510 Main St., Bridgeport, Conn.
80 White St., New York, N. Y. 133 No. Seventh St., Philadelphia Pa.
524 Atlantic Ave., Boston, Mass. 646 Washington Blvd., Chicago, Ill.
JENKINS BROS. Limited, Montreal, Canada; London, England.

Jenkins

BRONZE IRON STEEL

VALVES

Since 1864

EARTH THEORY

(*Continued from page 109*)

$$V_P=\sqrt{\frac{\lambda+2u}{\rho}} \quad \text{and} \quad V_S=\sqrt{\frac{u}{\rho}}$$

where ρ denotes the density and λ and u are the so-called Lame constants. The identification of these two phases as read on the seismograms with the two types of elastic waves appears to be established beyond a peradventure.

A shear wave may not be propagated by a fluid. For various reasons it is thought that the earth's core may be fluid. It becomes of interest to determine whether the *S*-wave penetrates the core or not. It has not so far been positively identified to the general satisfaction of those studying the problem. Further work is still being done along this line.

Let us now note a fact which is of fundamental importance. The seismological data are reduced on the basis of various assumptions which we shall discuss presently and which may or may not be true. But, even if all were rigorously established, these data could yield, for the deep-lying mantle, only the velocity of the wave or waves at various depths. Since the arrival of the *P*-phases can be determined with greater precision than can the *S*-phases, the law of variation of compressional wave velocity with depth is likeiy to be of a higher order of precision than any directly determined law of variation of shear wave velocity with depth. We may express V_P and V_S in somewhat different form, as follows:

$$V_P=\sqrt{\frac{E(1-\sigma)}{(1+\sigma)(1-2\sigma)e}} \quad V_S=\sqrt{\frac{E}{2(1+\sigma)e}}$$

where σ and E denote respectively two other elastic constants, namely Poisson's Ratio and Young's Modulus. If we suppose V_P and V_S to be determined with precision from observational data, we have but two equations to evaluate three unknowns. We may not say with certainty, for example, what is the law of variation of density with depth. We must make assumptions with regard to one of these quantities in order to evaluate the other two. Poisson's ratio has the value ¼ to ⅓ for most surface conditions. If we assume its value at any given depth and have values for V_P and V_S based on observational data, we may deduce values for the density and for Young's Modulus. But, it is evident that these deduced values will be no stronger than our assumption. The values for the shear wave velocities may be obtained from the deduced values for the compressional wave multiplied by a constant obtained by assuming a value for Poisson's ratio. For example, if that ratio be taken as ¼, the equations last given above reduce to a form yielding the ratio: $VP/V_S=\sqrt{3}$.

We see then that the seismological data yield only values for velocity at depth and that the compressional wave velocities are determined with the greater precision. These are based on the time-distance curve for the compressional wave — the *P*-curve. To make such a curve of any value, the earthquake on which it is based must be very sharply defined, the position of the focus, including its depth, must be determinable as must also the time of origin. As we have seen, there are but three regions in the world today where an earthquake may take place and such initial conditions for a *P*-curve be measured precisely. A further difficulty arises. In Figure 1 we have a map showing the azimuth and distance values for the ninety-odd stations whose records were made available to the writer for a study of the Japanese earthquake of March 7, 1927. It is apparent that there is a lack of stations for distance within the ranges 20 to 60 degrees and 100 to 180 degrees. The resulting *P*-curve is given in Figure 2. The same lack appears. There is not a point on the surface of the earth where we might expect to locate the origin time and the focus of an earthquake with precision and also have a distribution of stations throughout the entire distance range. Data from several earthquakes must be combined. For any focal region, however, it will be difficult to fill in with precision which shall be fully satisfactory the distance range, 20 to 50 degrees. Seismographic stations, well equipped, are still urgently required in certain strategic positions if we are to make a concerted effort to lift the determination of velocities within the earth to a higher plane of precision.

Mantle methods fall into two classes, indirect and direct. An indirect method involved the assumption of a law of variation of velocity with depth. Such methods are far from satisfactory and the results obtained may be dismissed as of an order lower than that obtained by the direct method. The latter, usually called the Wiechert-Herglotz method, is exceedingly laborious, involving many mechanical measurements of tangents to a satisfactorily accurate *P*-curve and the mechanical integration of a second, tediously deduced curve. The entire work must be repeated for each point on the desired velocity-depth curve. To be of value, meticulous care must be taken in each step of the mechanical procedure.

Some of the assumptions on which the method rests are:

1. The focus of the earthquake lies in the surface.
2. No discontinuities are traversed by the rays which reach the surface for each distance range concerned.
3. The velocity increases continuously with the depth, the velocity-depth function being also differentiable throughout.
4. The laws of reflection and refraction (Snell's law) applicable to light rays apply to the seismic rays within the earth.

NEW HI-WAY DRAG TAPE
FOR HEAVY DUTY ENGINEERING WORK
For body toughness, uniform temper, to best avoid kinking, continued legibility of numbers, and permanence of graduations, it has no equal. Cut at the left is actual size.
SEND FOR CIRCULARS OR GENERAL CATALOG
9|0
106 Lafayette Street New York City
THE LUFKIN RULE CO. Saginaw, Mich.

5. Each seismic ray is symmetrical about the radius through its vertex, the earth being considered a perfect sphere.
6. The true velocity (as differentiated from the apparent velocity given by the *P*-curve) for the surface horizon is constant for the entire earth. It is assumed to be known together with a *P*-curve, giving time-distance values for an earthquake whose focal position and origin time are known.

Realizing that the first two assumptions are certainly not tenable, it might be inferred that the method may not be applied. At the time it was developed, surficial discontinuities were not known to exist, and the focus of an earthquake was believed to lie so near the surface that no appreciable error would be introduced by ignoring the possible slight depths involved. With regard to assumption (6), we may say that the surface horizon velocities are not everywhere constant and may not be assumed to be so. However, in applying the method, Wiechert and Geiger, for example, assumed a constant true velocity at the surface which was very greatly in error, being about fifty per cent too great. They assumed that $V_P = 7.174$ km/sec. or less. This erroneous assumption was fortunate as we shall see and renders their results almost as free from error as regards this point as they would be if based on the best available modern data.

Surface methods determining the number of layers above the upper discontinuity, as we have called it, have been applied only in a few favorable regions as we have previously noted. But, wherever they have been applied, a true velocity of 7.75 to 8.0 km/sec. has been found for the compressional wave below that discontinuity.

If the mantle velocities were known accurately we could strip the core and obtain a *P*-curve for it. Unfortunately it would not be possible to determine the true velocity of the compressional wave for the horizon immediately below the lower discontinuity, without making further assumptions. Improved studies of the core velocities cannot be made until we have re-determined the mantle velocities on the basis of the best available *P*-curve data.

Some of the earth-structure theory we now hold is established beyond a doubt. Other parts present anomalies which invite further investigation. The subject is an intensely interesting one which, however, requires long years of patient research on the part of many. It behooves us, step by step, to distinguish carefully between those details which rest on strong foundations and those which are but indifferently supported by deductions from observational data, made on the basis of assumptions which are but tentatively adopted.

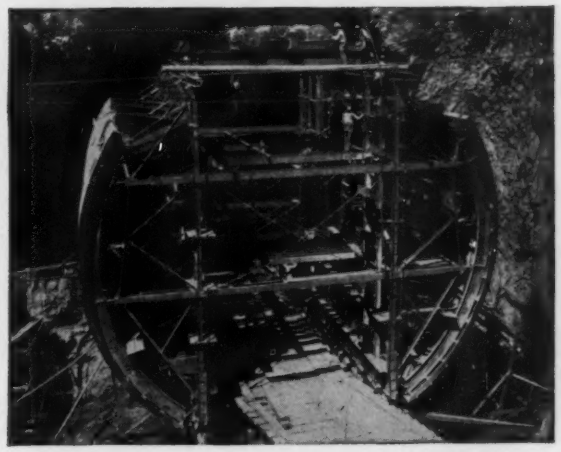
ENGINEERING DIGEST

(*Continued from page 113*)

2. In the same section, the United States will build and operate the works in the Thousand Island Section above Oak Point, and a canal and lock opposite Barnhart Island.
3. To restore and maintain the lake levels in their natural range, compensating works shall be built in the Niagara and St. Clair Rivers, at the expense of both countries.

The entire project, costing half a billion dollars, eventually will develop power totalling 5,000,000 horsepower, in addition to furnishing a direct deep-water route from the Middle West to Europe.

See HOOVER DAM in the making



Such activities as pouring three-foot concrete circular walls by means of this fifty-foot mold which travels on tracks, are all in the day's work at Hoover Dam site. See this spectacular engineering project in the making, enroute to or from Southern California via Union Pacific's Overland Route.

Illustrated folder containing 30" x 17" panoramic map of Hoover Dam area, on request. Address W. S. Basinger, Passenger Traffic Manager, Room 502, Union Pacific System, Omaha, Nebr.

UNION PACIFIC

THE HOOVER DAM ROUTE

STANDARDS FOR THE RADIO

(*Continued from page 115*)

The I. R. E. standards have formed the basis for the commercial testing and standardization of broadcast receivers and vacuum tubes since standards on these matters were first prepared in 1927, and are extensively used in other countries besides the United States. The report on "Standard Tests of Broadcast Radio Receivers" has recently been revised to include methods particularly applicable to testing the characteristics of superheterodyne receivers. The recent popular interest shown in high frequency receivers and "short wave concerters" has made it necessary for the Institute to prepare "Standard Tests for High Frequency Receivers" as well. This report includes data on the measurement of characteristics of regenerative receivers, a problem to which no solution of national scope could be obtained until the general consent of those most active and most interested in the production and design of such receivers could be obtained. The I. R. E. "Standard Methods of Testing Vacuum Tubes" likewise have been in use by the radio industry since its publication in 1927. A recent revision of these standards provides test methods which are suitable for four, five, and other multielectrode tubes and phototubes as well as for the more familiar triodes.

Since the Radio Manufacturers Association is a federation of manufacturing concerns, its standardization work deals mainly with the problems which a radio manufacturer has to face in building, selling, and servicing his products. Its standards cover such matters as

(*Continued on next page*)

ENGINEERING EDUCATION

(*Continued from page 105*)

about fifteen per cent of the time to such studies. Keen and ambitious men naturally have wide interests, and, if equipped with minds capable of penetrating analysis, should be capable of independent, discriminating reading and study in practically any field. However, even if additional formal instruction in such studies should be considered essential, it would seem preferable to undertake this after the sound development of the mental process rather than before. The graduate of an engineering school who is equipped with a mind disciplined to rigorous thinking and accustomed to diligent application to study ought to be able to qualify for the Bachelor of Arts degree in two years, if bright high school graduates can do so in three years, as some who wish to exert themselves actually do in even the foremost colleges of liberal arts. The engineering-school graduate whose mind has been disciplined by processes wherein the results can be tested is less likely to go astray in his reasoning in fields where the results cannot be tested than a student with an undisciplined mind. Furthermore, the greater maturity of the engineering-school graduate would make more likely a sympathetic understanding of much in literature which is incomprehensible to many of some years' less observation and experience.

The problem is really one of determination of relative values in the use of time allotted to formal education. As the store of knowledge continues to grow indefinitely the period of formal education cannot be extended likewise and the curriculum expanded. To do so generally would require most students to spend so much time thinking the thoughts of other men that there would be no time left for them to have any thoughts of their own. Many men remain schoolboys too long as it is. They should be called upon to do their own thinking and to accept appropriate responsibility in the ordering of their affairs at a much earlier time than is in general characteristic of present-day American practice.

While the more facts a man can have at his immediate command without sacrifice of analytical power the better, the storehouses of knowledge must be the libraries and museums, man playing the role of manipulator. Even now there is much more knowledge in the world than is being put into intelligent, effective use. If not a single iota should be added to the store of knowledge from this day forth, the world could be made an infinitely happier, more beautiful, and more comfortable place in which to live if a sufficient number of men of sound intellect could put their minds on the problem. If, as it seems to some, the scientific era has fallen short of its potentialities in terms of human happiness, the reason must be ascribed to two sources: (1) too few people can think with sufficient soundness that they dare to trust the dictates of their minds in preference to those of their instincts and emotions, and hence too few are qualified to take guiding parts or even participate with intelligence in a complex society; and (2) a few thousand years or more of Christianity, Mohammedanism, Buddhism, and other isms have not put a sufficient amount of integrity into men's natures or taken a sufficient amount of selfishness out of them to prevent the thwarting of nullification of much work of the more generous and altruistic spirits towards a better civilization. Certainly the first situation must be attacked by centering the educational process around the development of rigorous thinking, and it is not inconceivable but that the resulting clarification of view between cause and effect and the unavoidable recognition of reciprocal relations might go a long way toward amelioration of the second. The remarkable additions to the store of knowledge which have done much to enrich our present conditions of life have been due to the labors of a very small fraction of the population. If in application this knowledge has frequently been used unintelligently, ineffectively and dishonestly, the blame cannot be laid at the door of those who brought the knowledge into the world. The intelligent use of the store of knowledge is the responsibility of each and all.

THE FUTURE

(*Continued from page 104*)

visible, stands Technology. On either side the park extends, and nowhere may a factory be seen. East of Walker Memorial, and beyond the interconnected dormitory group, are about twenty tennis courts. West of the main set of buildings are other groups of buildings, all separated. These are the units of the new fraternity grouping plan, and the homes of some of the officers of the school. Except for this it seems to be the same old school, business-like, fascinating, and the most famous center of engineering education.

None of this may come to pass. Something unforeseen may change everything, or put all we know completely out of existence. But certainly we are justified when we suppose that Technology will continue in its upward path. We can expect progress in the next twenty years no less startling than that of the past two decades.

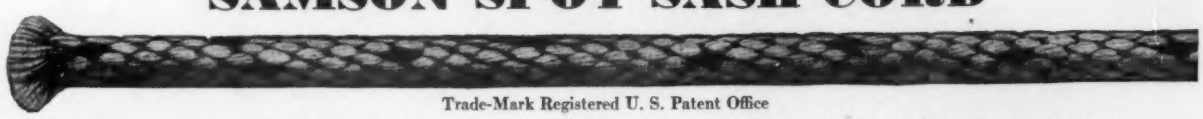
RADIO

(*Continued from page 119*)

color coding for various sizes of resistors, dimensional standards of essential units which might require replacement, voltage, current, and power ratings of the component units of broadcast receivers, specifications for materials and the like.

Quite naturally the work of the Institute of Radio Engineers and the Radio Manufacturers Association frequently meet on common ground, for it is impossible to draw a sharp line of distinction between the purely engineering and the purely manufacturing problems.

SAMSON SPOT SASH CORD



Trade-Mark Registered U. S. Patent Office

Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds, and colors for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.

CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

SAMSON CORDAGE WORKS : : **89 Broad Street, Boston 9, Mass.**

THE MURRAY PRINTING COMPANY, CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASSACHUSETTS

The MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers Courses in Engineering and Science, each of four years' duration, leading to the degree of Bachelor of Science in:

AERONAUTICAL ENGINEERING
ARCHITECTURAL ENGINEERING
BIOLOGY AND PUBLIC HEALTH
BUILDING CONSTRUCTION
BUSINESS AND ENGINEERING ADMINISTRATION
CHEMICAL ENGINEERING
CHEMICAL ENGINEERING PRACTICE
CHEMISTRY
CIVIL ENGINEERING
ELECTRICAL ENGINEERING
GENERAL SCIENCE
GENERAL ENGINEERING
GEOLOGY
INDUSTRIAL BIOLOGY
MATHEMATICS
MECHANICAL ENGINEERING
METALLURGY
MILITARY ENGINEERING
MINING ENGINEERING
NAVAL ARCHITECTURE AND MARINE ENGINEERING
PHYSICS
SANITARY ENGINEERING

The Course in Architecture is of five years' duration, and leads to the degree of Bachelor in Architecture. Five-Year Coöperative Courses in Electrical Engineering and Railroad Operation leading to the degrees of Bachelor of Science and Master of Science are also offered.

Graduate Courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are offered. The Courses leading to the degree of Master of Science include Coöperative Courses in Chemical Engineering Practice and Fuel and Gas Engineering.

The better high schools and other preparatory schools in the United States offer adequate preparation for the required entrance examinations given by the College Entrance Examination Board in June, or by the Institute in September.

Graduates of colleges or of scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding approximately to at least one year's work at the Institute, are admitted to such advanced standing as is warranted by their previous training, and are given credit for our required subjects, including the entrance requirements, so far as they have been satisfactorily completed.

The Summer Session extending from June to September includes most of the subjects given during the academic year and in addition special courses for teachers.

Any of the following publications will be sent free upon request

CATALOGUE FOR THE ACADEMIC YEAR
(WHICH INCLUDES THE ADMISSION REQUIREMENTS)

SUMMER SESSION CATALOGUE

GRADUATE STUDY AND RESEARCH

Correspondence should be addressed to the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

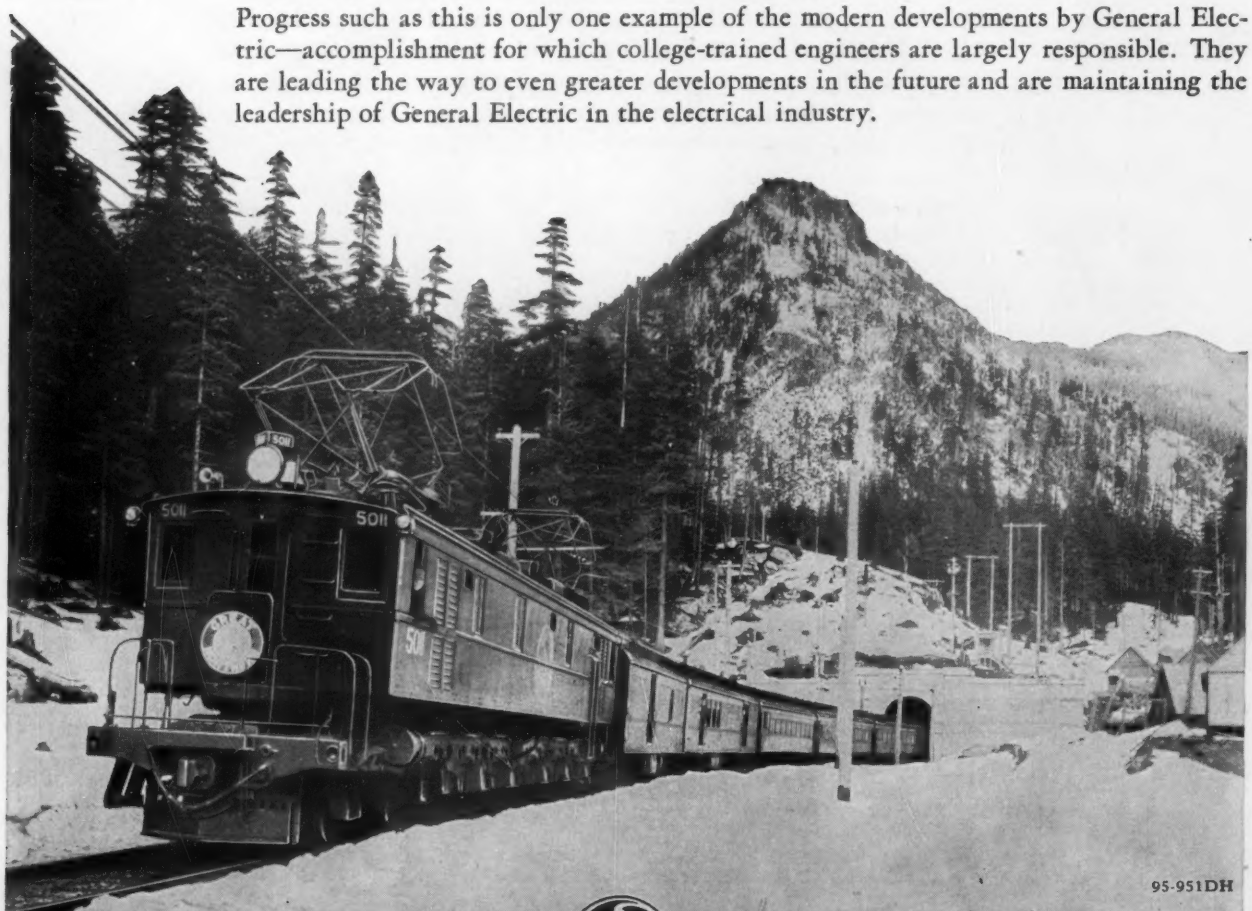
SUBSCRIPTION PER YEAR, $1.50. Address all communications to The Tech Engineering News, Walker Memorial, Cambridge A, Massachusetts. Telephone, University 6864. Advertising rates upon application. Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920. Published monthly throughout the school year by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer coöperation between Alumni and undergraduates.

A Century of Rail Transportation

A RACE between the horse and the locomotive has started. The *De Witt Clinton*, that awesome "iron horse," is puffing and plodding away from Albany to Schenectady at the high rate of 22 miles per hour. The snorting monster, showering sparks and smoke all over its passengers, frightens cattle and farmers' horses all along the way. The *De Witt Clinton* arrives in Schenectady, having covered the seventeen miles from Albany in 46 minutes. Trailing behind, seven horse-drawn coaches arrive a half-hour later. The horse has met its first reverse.

To-day, more than a century later, we see a mighty 260-ton General Electric locomotive of the Great Northern Railway as it emerges from the scenic west portal of the 8-mile Cascade tunnel in Washington. What a contrast to the quaint *De Witt Clinton!* This modern 3000-horsepower locomotive smoothly and swiftly pulls a thousand-ton train over the many grades of the Great Northern route.

Progress such as this is only one example of the modern developments by General Electric—accomplishment for which college-trained engineers are largely responsible. They are leading the way to even greater developments in the future and are maintaining the leadership of General Electric in the electrical industry.



95-951DH

GENERAL ELECTRIC